

Supplement of SOIL, 6, 195–213, 2020
<https://doi.org/10.5194/soil-6-195-2020-supplement>
© Author(s) 2020. This work is distributed under
the Creative Commons Attribution 4.0 License.



Supplement of

Boreal-forest soil chemistry drives soil organic carbon bioreactivity along a 314-year fire chronosequence

Benjamin Andrieux et al.

Correspondence to: Benjamin Andrieux (benjamin.andrieux@uqat.ca)

The copyright of individual parts of the supplement might differ from the CC BY 4.0 License.

Table S1: Path coefficients and model-averaged estimators for each of the *a priori* hypothesized causal relationship among variables (arrows) for the O layer.

Direct causal effects

Model	MAT ↓ C _{BioR}	GDD5 ↓ C _{BioR}	MAP ↓ C _{BioR}	WB ↓ C _{BioR}	Sand ↓ C _{BioR}	Silt ↓ C _{BioR}	Clay ↓ C _{BioR}	TSF ↓ C _{BioR}	pH ↓ C _{BioR}	IMD ↓ C _{BioR}	Mn ↓ C _{BioR}
O1	0.02	-	-	-	-0.10	-	-	0.25 *	0.36 **	0.09	0.35 **
O1	0.03	-	-	-	-	0.08	-	0.25 *	0.36 **	0.09	0.35 **
O1	0.02	-	-	-	-	-	0.11	0.24 *	0.36 **	0.08	0.34 **
O1	-	-0.04	-	-	-0.11	-	-	0.25 *	0.36 **	0.08	0.33 **
O1	-	-0.03	-	-	-	0.09	-	0.25 *	0.35 **	0.08	0.33 **
O1	-	-0.05	-	-	-	-	0.12	0.24 *	0.35 **	0.06	0.31 **
O1	-	-	-0.29 **	-	-0.17	-	-	0.28 *	0.34 **	0.00	0.35 ***
O1	-	-	-0.30 **	-	-	0.16	-	0.28 **	0.34 **	0.01	0.35 ***
O1	-	-	-0.26 *	-	-	-	0.12	0.26 *	0.33 **	0.00	0.34 **
O1	-	-	-	-0.30 **	-0.16	-	-	0.28 **	0.35 **	0.01	0.39 ***
O1	-	-	-	-0.31 **	-	0.15	-	0.28 **	0.34 **	0.01	0.40 ***
O1	-	-	-	-0.26 *	-	-	0.10	0.26 *	0.34 **	0.00	0.38 ***
O2	-	-	-	-	-	-	-	0.25 *	0.34 **	0.08	0.34 **
O2	-	-	-	-	-	-	-	0.25 *	0.34 **	0.08	0.34 **
O2	-	-	-	-	-	-	-	0.25 *	0.34 **	0.08	0.34 **
O2	-	-	-	-	-	-	-	0.25 *	0.34 **	0.08	0.34 **
O2	-	-	-	-	-	-	-	0.25 *	0.34 **	0.08	0.34 **
O2	-	-	-	-	-	-	-	0.25 *	0.34 **	0.08	0.34 **
O2	-	-	-	-	-	-	-	0.25 *	0.34 **	0.08	0.34 **
O2	-	-	-	-	-	-	-	0.25 *	0.34 **	0.08	0.34 **
O2	-	-	-	-	-	-	-	0.25 *	0.34 **	0.08	0.34 **
O2	-	-	-	-	-	-	-	0.25 *	0.34 **	0.08	0.34 **
O2	-	-	-	-	-	-	-	0.25 *	0.34 **	0.08	0.34 **
O2	-	-	-	-	-	-	-	0.25 *	0.34 **	0.08	0.34 **
Model-averaged estimator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.34	0.08	0.34

Note: *Model*: model name; *MAT*: mean annual temperature; *GDD5*: growing degree-day above 5°C; *MAP*: mean annual precipitation; *WB*: water balance; *Sand*: sand content of the mineral soil; *Silt*: silt content of the mineral soil; *Clay*: clay content of the mineral soil; *TSF*: time since fire; *pH*: pH of the O layer; *IMD*: index of moss dominance; *Mn*: exchangeable manganese; *C_{BioR}*: carbon bioreactivity of the O layer. The model that best fitted the data is highlighted by bold font. (*) $p \leq 0.05$; (**) $p \leq 0.01$; (***) $p \leq 0.001$.

Indirect causal effects

Model	TSF ↓ pH	IMD ↓ pH	MAT ↓ IMD	GDD5 ↓ IMD	MAP ↓ IMD	WB ↓ IMD	Sand ↓ IMD	Silt ↓ IMD	Clay ↓ IMD
O1	-	-	-	-	-	-	-	-	-
O1	-	-	-	-	-	-	-	-	-
O1	-	-	-	-	-	-	-	-	-
O1	-	-	-	-	-	-	-	-	-

O1	-	-	-	-	-	-	-	-	-	-	-	-
O1	-	-	-	-	-	-	-	-	-	-	-	-
O1	-	-	-	-	-	-	-	-	-	-	-	-
O1	-	-	-	-	-	-	-	-	-	-	-	-
O1	-	-	-	-	-	-	-	-	-	-	-	-
O1	-	-	-	-	-	-	-	-	-	-	-	-
O1	-	-	-	-	-	-	-	-	-	-	-	-
O1	-	-	-	-	-	-	-	-	-	-	-	-
O2	-0.32 **	0.30 **	-0.22	-	-	-	-	0.06	-	-	-	-
O2	-0.32 **	0.30 **	-0.22	-	-	-	-	-	-0.09	-	-	-
O2	-0.32 **	0.30 **	-0.24 *	-	-	-	-	-	-	-	0.08	-
O2	-0.32 **	0.30 **	-	-0.19	-	-	-	0.05	-	-	-	-
O2	-0.32 **	0.30 **	-	-0.19	-	-	-	-	-0.09	-	-	-
O2	-0.32 **	0.30 **	-	-0.22	-	-	-	-	-	-	0.09	-
O2	-0.32 **	0.30 **	-	-	-0.32 **	-	-	0.01	-	-	-	-
O2	-0.32 **	0.30 **	-	-	-0.32 *	-	-	-	-0.04	-	-	-
O2	-0.32 **	0.30 **	-	-	-0.33 **	-	-	-	-	-	0.06	-
O2	-0.32 **	0.30 **	-	-	-	-	-0.26 *	0.04	-	-	-	-
O2	-0.32 **	0.30 **	-	-	-	-	-0.26 *	-	-	-0.06	-	-
O2	-0.32 **	0.30 **	-	-	-	-	-0.27 *	-	-	-	0.04	-
Model-averaged estimator	-0.32	0.30	-0.01	-0.01	-0.25	-0.03	0.00	-0.01	0.05	-	-	-

Note: *Model*: model name; *MAT*: mean annual temperature; *GDD5*: growing degree-day above 5°C; *MAP*: mean annual precipitation; *WB*: water balance; *Sand*: sand content of the mineral soil; *Silt*: silt content of the mineral soil; *Clay*: clay content of the mineral soil; *TSF*: time since fire; *pH*: pH of the O layer; *IMD*: index of moss dominance; *C_{BioR}*: carbon bioreactivity of the O layer. The model that best fitted the data is highlighted by bold font. (*) $p \leq 0.05$; (**) $p \leq 0.01$; (***) $p \leq 0.001$.

Table S2: Path coefficients and model-averaged estimators for each of the *a priori* hypothesized causal relationships among variables (arrows) for the mineral soil.

Direct causal effects

Model	MAT ↓ C _{BioR}	GDD5 ↓ C _{BioR}	MAP ↓ C _{BioR}	WB ↓ C _{BioR}	Sand ↓ C _{BioR}	Silt ↓ C _{BioR}	Clay ↓ C _{BioR}	TSF ↓ C _{BioR}	pH ↓ C _{BioR}	Mpy ↓ C _{BioR}	Mn ↓ C _{BioR}	Al ↓ C _{BioR}
MIN1	0.24 *	-	-	-	0.23	-	-	-0.11	-0.19	-0.32 *	0.15	-
MIN1	0.21	-	-	-	0.21	-	-	0.06	-0.27 *	-0.3 *	-	-0.42 ***
MIN1	0.24 *	-	-	-	-	-0.22 -0.24	-	-0.11	-0.18	-0.33 *	0.14	-
MIN1	0.21	-	-	-	-	*	-	0.06	-0.26 *	-0.31 **	-	-0.44 ***
MIN1	0.23	-	-	-	-	-	-0.15	-0.11	-0.25	-0.3 *	0.17	-
MIN1	0.18	-	-	-	-	-	-0.02	0.06	-0.31 *	-0.29 *	-	-0.42 **
MIN1	-	0.21	-	-	0.24 *	-	-	-0.08	-0.16	-0.28 *	0.15	-
MIN1	-	0.18	-	-	0.22	-	-	0.08	-0.25 *	-0.26 *	-	-0.42 ***
MIN1	-	0.2	-	-	-	-0.22 -0.24	-	-0.08	-0.15	-0.28 *	0.14	-
MIN1	-	0.17	-	-	-	*	-	0.09	-0.23	-0.27 *	-	-0.44 ***
MIN1	-	0.2	-	-	-	-	-0.17	-0.09	-0.23	-0.26 *	0.17	-
MIN1	-	0.14	-	-	-	-	-0.03	0.08	-0.29 *	-0.26 *	-	-0.42 **
MIN1	-	-	0.24	-	0.25 *	-	-	-0.09	-0.2	-0.33 **	0.13	-

Model	MAT ↓ C _{BioR}	GDD5 ↓ C _{BioR}	MAP ↓ C _{BioR}	WB ↓ C _{BioR}	Sand ↓ C _{BioR}	Silt ↓ C _{BioR}	Clay ↓ C _{BioR}	TSF ↓ C _{BioR}	pH ↓ C _{BioR}	Mpy ↓ C _{BioR}	Mn ↓ C _{BioR}	Al ↓ C _{BioR}
MIN1	-	-	0.22	-	0.23 *	-	-	0.07	-0.28 *	-0.31 **	-	-0.42 ***
MIN1	-	-	0.25 *	-	-	-0.26 *	-	-0.09	-0.18	-0.34 **	0.11	-
MIN1	-	-	0.23 *	-	-	-0.28 *	-	0.07	-0.27 *	-0.33 **	-	-0.44 ***
MIN1	-	-	0.18	-	-	-	-0.12	-0.09	-0.24	-0.3 *	0.14	-
MIN1	-	-	-	-	-	-	0	0.07	-0.31 *	-0.3 *	-	-0.42 **
MIN1	-	-	-	0.16	0.22	-	-	-0.08	-0.17	-0.32 *	0.12	-
MIN1	-	-	-	0.15	0.21	-	-	0.08	-0.27 *	-0.31 *	-	-0.42 ***
MIN1	-	-	-	0.18	-	-0.23 -0.26	-	-0.08	-0.16	-0.33 *	0.11	-
MIN1	-	-	-	0.17	-	*	-	0.08	-0.25 *	-0.32 **	-	-0.44 ***
MIN1	-	-	-	0.12	-	-0.11	-0.11	-0.08	-0.22	-0.3 *	0.14	-
MIN1	-	-	-	0.11	-	0.01	0.01	0.08	-0.3 *	-0.3 *	-	-0.43 **
MIN2	-	-	-	-	-	-	-	-0.07	-0.18	-0.28 *	0.12	-
MIN2	-	-	-	-	-	-	-	0.09	-0.27 *	-0.27 *	-	-0.43 ***
MIN2	-	-	-	-	-	-	-	-0.07	-0.18	-0.28 *	0.12	-
MIN2	-	-	-	-	-	-	-	0.09	-0.27 *	-0.27 *	-	-0.43 ***
MIN2	-	-	-	-	-	-	-	-0.07	-0.18	-0.28 *	0.12	-
MIN2	-	-	-	-	-	-	-	0.09	-0.27 *	-0.27 *	-	-0.43 ***
MIN2	-	-	-	-	-	-	-	-0.07	-0.18	-0.28 *	0.12	-
MIN2	-	-	-	-	-	-	-	0.09	-0.27 *	-0.27 *	-	-0.43 ***
MIN2	-	-	-	-	-	-	-	-0.07	-0.18	-0.28 *	0.12	-
MIN2	-	-	-	-	-	-	-	0.09	-0.27 *	-0.27 *	-	-0.43 ***
MIN2	-	-	-	-	-	-	-	-0.07	-0.18	-0.28 *	0.12	-
MIN2	-	-	-	-	-	-	-	0.09	-0.27 *	-0.27 *	-	-0.43 ***
MIN2	-	-	-	-	-	-	-	-0.07	-0.18	-0.28 *	0.12	-
MIN2	-	-	-	-	-	-	-	0.09	-0.27 *	-0.27 *	-	-0.43 ***
MIN2	-	-	-	-	-	-	-	-0.07	-0.18	-0.28 *	0.12	-
MIN2	-	-	-	-	-	-	-	0.09	-0.27 *	-0.27 *	-	-0.43 ***
MIN2	-	-	-	-	-	-	-	-0.07	-0.18	-0.28 *	0.12	-
MIN2	-	-	-	-	-	-	-	0.09	-0.27 *	-0.27 *	-	-0.43 ***
MIN2	-	-	-	-	-	-	-	-0.07	-0.18	-0.28 *	0.12	-
MIN2	-	-	-	-	-	-	-	0.09	-0.27 *	-0.27 *	-	-0.43 ***
MIN2	-	-	-	-	-	-	-	-0.07	-0.18	-0.28 *	0.12	-
MIN2	-	-	-	-	-	-	-	0.09	-0.27 *	-0.27 *	-	-0.43 ***
MIN2	-	-	-	-	-	-	-	-0.07	-0.18	-0.28 *	0.12	-
MIN2	-	-	-	-	-	-	-	0.09	-0.27 *	-0.27 *	-	-0.43 ***
Model-averaged estimator	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.05	-0.25	-0.27	0.03	-0.32

Note: *Model*: model name; *MAT*: mean annual temperature; *GDD5*: growing degree-day above 5°C; *MAP*: mean annual precipitation; *WB*: water balance; *Sand*: sand content of the mineral soil; *Silt*: silt content of the mineral soil; *Clay*: clay content of the mineral soil; *TSF*: time since fire; *pH*: pH of the mineral soil; *Mpy*: pyrophosphate extractable metals; *Mn*: exchangeable manganese; *Al*: exchangeable aluminum; *C_{BioR}*: carbon bioreactivity of the mineral soil. The model that best fitted the data is highlighted by bold font. (*) $p \leq 0.05$; (**) $p \leq 0.01$; (***) $p \leq 0.001$.

Indirect causal effects

Model	MAT ↓ Mpy	GDD5 ↓ Mpy	MAP ↓ Mpy	WB ↓ Mpy	pH ↓ Mpy	TSF ↓ pH	Sand ↓ Mn	Silt ↓ Mn	Clay ↓ Mn	Sand ↓ Al	Silt ↓ Al	Clay ↓ Al	pH ↓ Mn	pH ↓ Al
-------	-----------------	------------------	-----------------	----------------	----------------	----------------	-----------------	-----------------	-----------------	-----------------	-----------------	-----------------	---------------	---------------

MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN2	0.14	-	-	-	-0.37 **	-0.16	-0.07	-	-	-	-	-	0.23	-
MIN2	0.14	-	-	-	-0.37 **	-0.16	-	-	-	-0.02	-	-	-	-0.37 **
MIN2	0.14	-	-	-	-0.37 **	-0.16	-	0.01	-	-	-	-	0.24 *	-
MIN2	0.14	-	-	-	-0.37 **	-0.16	-	-	-	-	-0.05	-	-	-0.35 **
MIN2	0.14	-	-	-	-0.37 **	-0.16	-	-	0.21	-	-	-	0.27 *	-
MIN2	0.14	-	-	-	-0.37 **	-0.16	-	-	-	-	-	0.24 *	-	-0.33 **
MIN2	-	-0.04	-	-	-0.35 **	-0.16	-0.07	-	-	-	-	-	0.23	-
MIN2	-	-0.04	-	-	-0.35 **	-0.16	-	-	-	-0.02	-	-	-	-0.37 **
MIN2	-	-0.04	-	-	-0.35 **	-0.16	-	0.01	-	-	-	-	0.24 *	-
MIN2	-	-0.04	-	-	-0.35 **	-0.16	-	-	-	-	-0.05	-	-	-0.35 **
MIN2	-	-0.04	-	-	-0.35 **	-0.16	-	-	0.21	-	-	-	0.27 *	-
MIN2	-	-0.04	-	-	-0.35 **	-0.16	-	-	-	-	-	0.24 *	-	-0.33 **
MIN2	-	-	0.18	-	-0.39 **	-0.16	-0.07	-	-	-	-	-	0.23	-
MIN2	-	-	0.18	-	-0.39 **	-0.16	-	-	-	-0.02	-	-	-	-0.37 **
MIN2	-	-	0.18	-	-0.39 **	-0.16	-	0.01	-	-	-	-	0.24 *	-
MIN2	-	-	0.18	-	-0.39 **	-0.16	-	-	-	-	-0.05	-	-	-0.35 **
MIN2	-	-	0.18	-	-0.39 **	-0.16	-	-	0.21	-	-	-	0.27 *	-
MIN2	-	-	0.18	-	-0.39 **	-0.16	-	-	-	-	-	0.24 *	-	-0.33 **
MIN2	-	-	-	0.21	-0.38 ***	-0.16	-0.07	-	-	-	-	-	0.23	-
MIN2	-	-	-	0.21	-0.38 ***	-0.16	-	-	-	-0.02	-	-	-	-0.37 **
MIN2	-	-	-	0.21	-0.38 ***	-0.16	-	0.01	-	-	-	-	0.24 *	-
MIN2	-	-	-	0.21	-0.38 ***	-0.16	-	-	-	-	-0.05	-	-	-0.35 **
MIN2	-	-	-	0.21	-0.38 ***	-0.16	-	-	0.21	-	-	-	0.27 *	-
MIN2	-	-	-	0.21	-0.38 ***	-0.16	-	-	-	-	-	0.24 *	-	-0.33 **
Model-averaged estimator	0.01	0.00	0.03	0.11	-0.34	-0.15	0.00	0.00	0.03	0.00	0.00	0.17	0.05	-0.24

Note: *Model*: model name; *MAT*: mean annual temperature; *GDD5*: growing degree-day above 5°C; *MAP*: mean annual precipitation; *WB*: water balance; *Sand*: sand content of the mineral soil; *Silt*: silt content of the mineral soil; *Clay*: clay content of the mineral soil; *TSF*: time since fire; *pH*: pH of the mineral soil; *Mpy*: pyrophosphate extractable metals; *Mn*: exchangeable manganese; *Al*: exchangeable aluminum; *C_{BioR}*: carbon bioreactivity of the mineral soil. The model that best fitted the data is highlighted by bold font. (*) $p \leq 0.05$; (**) $p \leq 0.01$; (***) $p \leq 0.001$.

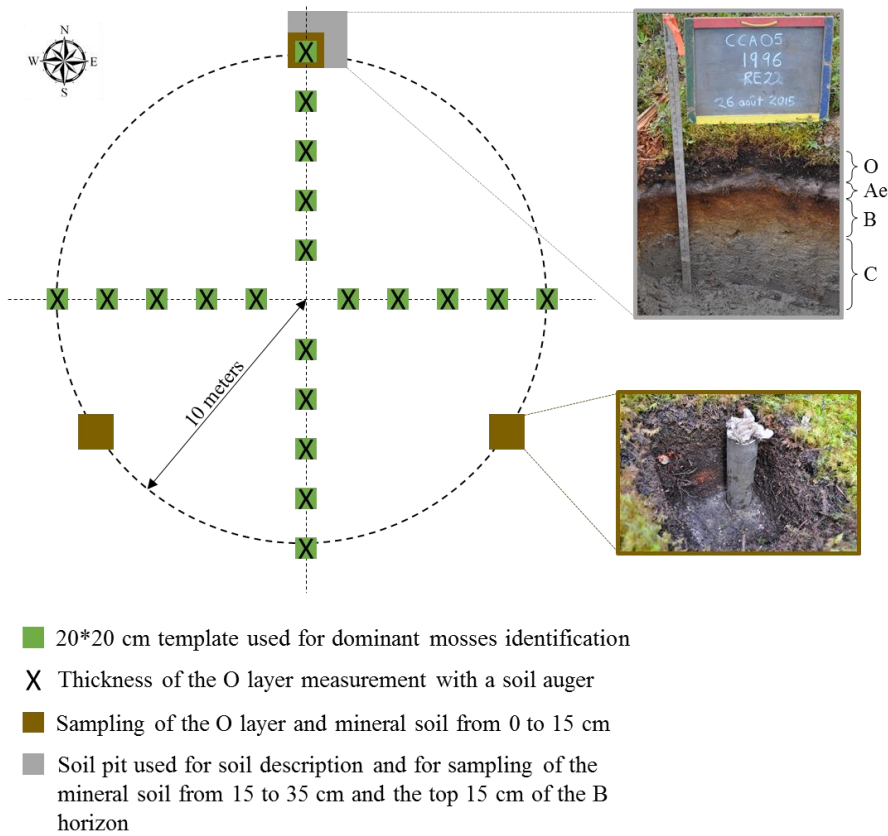


Figure S1: Diagram of the sampling plot.

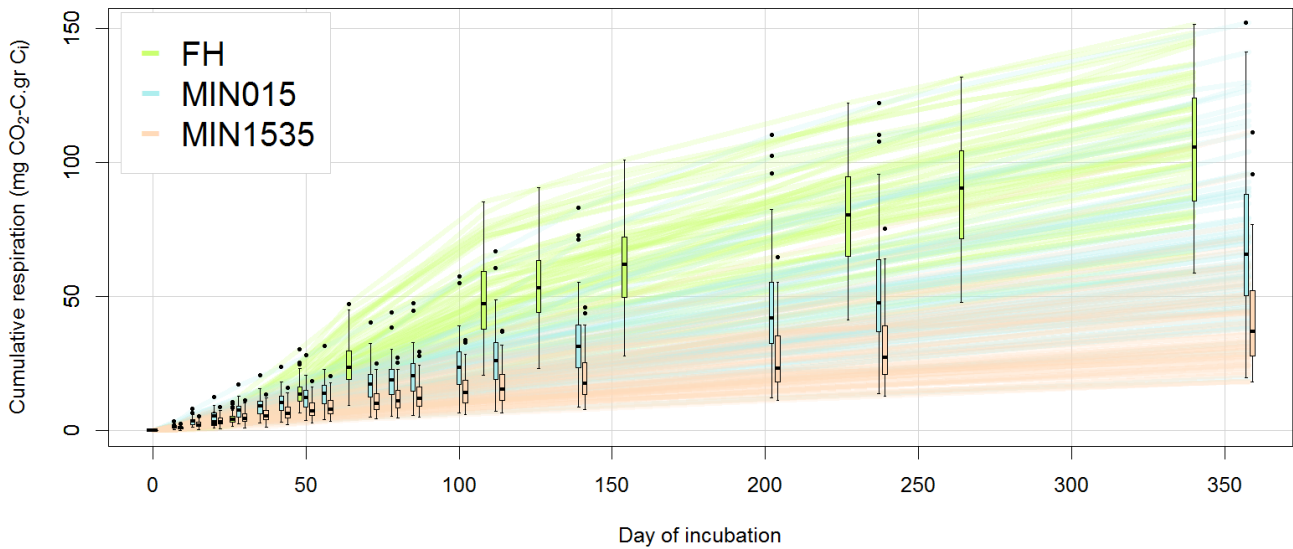


Figure S2: Cumulative specific respiration (R_s) as a function of the sampling Julian day. Boxplots represent the distribution of R_s values for each of the soil layers for each sampling day. Lines are drawn for each of the samples. *FH* (green): O layer; *MIN015* (blue): mineral soil, top 15 cm; *MIN1535* (salmon): mineral soil, from 15 to 35 cm.

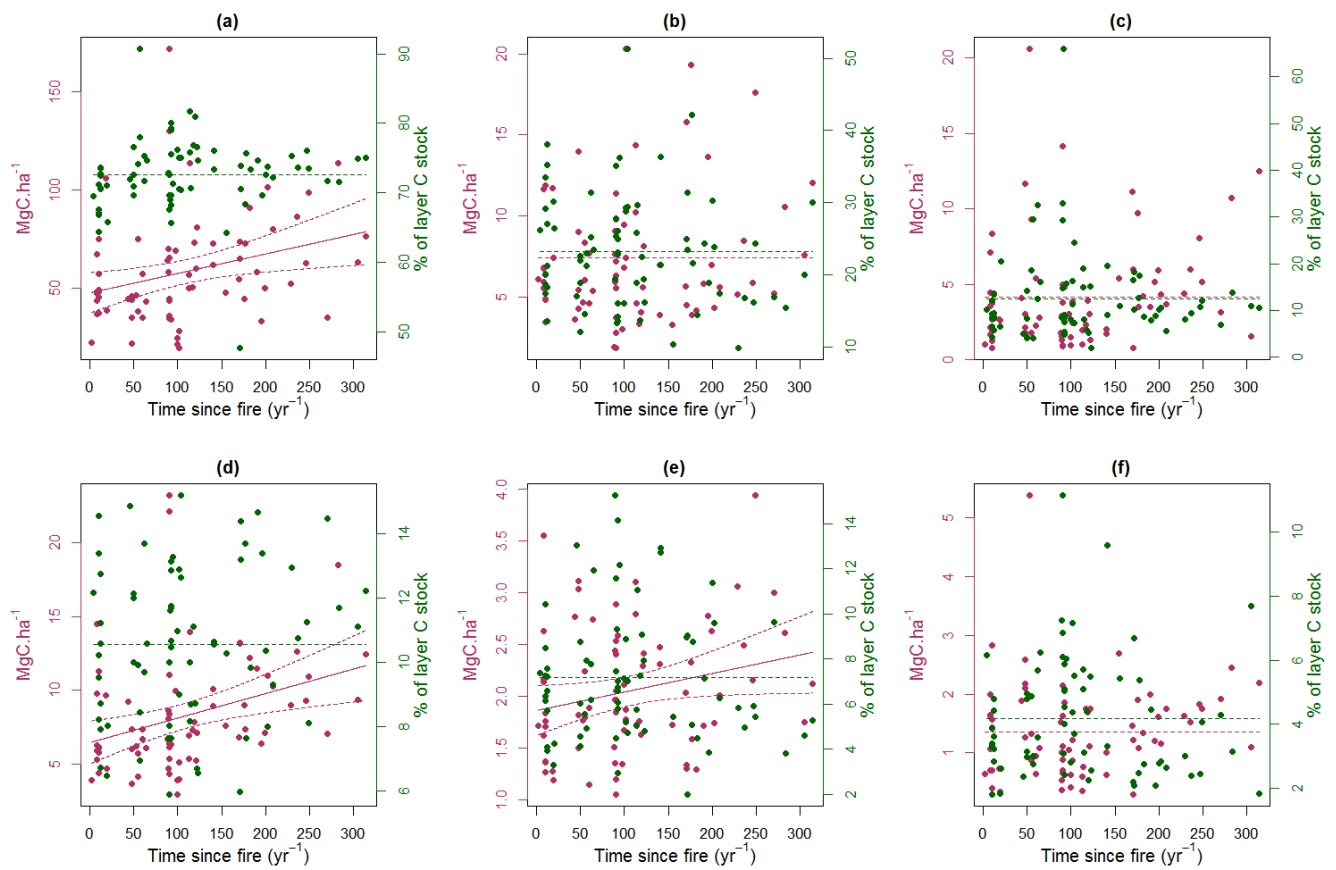


Figure S3: Acid-insoluble soil carbon stock and fraction (a-c) and bioreactive soil carbon stock and fraction (d-f) as a function of time since fire for the O layer (a, d), the top 15 cm of the mineral soil (b, e) and the mineral soil from 15 to 35 cm (c, f). Stock: maroon dots; proportion relative to total soil carbon stock: green dots. Plain line and dashed lines: prediction with confidence interval, respectively. Dashed line only: mean, where linear relationship was found to be not significant ($p < 0.05$). See also Table 2.